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Sources and Values of Honey

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A great number of flowering plants provide the nectars that bees gather, modify into honey, and store in combs. The nectars differ as the species of the plants differ. So honey, which is a natural, ready-made confection, is not a specific, uniform product. It varies from the pale-gold, mild-flavored honeys from fireweed and sweetclover to the strong-flavored, molasseslike honey from cultivated buckwheat.

To produce honey, the bee draws up the nectar from flowers and stores it in her honey sac while in the field. At the hive, the nectar is concentrated by the evaporation of water and deposited in open cells in comb. Here, more water is evaporated until, by the time the honey has become well ripened, the water content is only 18 percent or less. When the cell has been filled with ripened honey, it is sealed with a cap of wax. Such honey, with the cells in which it is contained, is called comb honey.

Section comb honey is capped comb honey in the thin wooden sections or frames in which it is produced. A section weighs 10 to 15 ounces, depending upon how well it is filled.

Extracted honey is liquid honey that has been separated from the uncrushed comb, usually by centrifugal force developed by whirling the uncapped (i. e., decapped) comb in an extractor. Liquid honey can be separated by gravity (by suspending macerated comb in a cotton jelly bag) or by pressing the honey out of the comb. Extracted honey is marketed in both liquid and crystallized forms.

Chunk honey, also called bulk-comb honey, packed chiefly in the Southeastern States, consists of pieces of comb honey surrounded by, or immersed in, liquid honey. Custom decrees that the weight of the comb honey shall equal not less than 40 percent of the total net weight. Some exception has been noted for packs in small-mouth jars, which do not readily admit that much comb.

Most of the honey of commerce is extracted. Extracting is done by the beekeeper, who strains the warm honey to remove particles of wax and other foreign matter. If it is to be stored or sold in bulk, the honey is usually transferred to 60-pound honey cans, much like the common rectangular 5-gallon oil can. Sometimes bulk honey is marketed in barrels.

The commercial floral-nectar types of honey, including natural blends, produced in this country number scarcely more than two score. Types produced in large quantities are few. Nearly 65 percent of our total honey crop is from the clovers and alfalfa. Contributions from the blossoms of lima beans, mesquite, and vetches raise the total from legumes to possibly 70 percent of the crop. Clover honeys and most of those from the other legumes have mild, pleasant flavors, and are comparatively light in color.

Honeys from orange and other citrus blossoms are produced in important volume, and, whether from California, Florida, or Texas, are prized because of their attractive flavor and aroma and pale to golden color. California sage honey and its natural blends are market favorites. Honey from tupelo, produced chiefly in swampy areas of Florida and Georgia, probably is our sweetest commercial honey and has a

delicate, spicy flavor. Others prominent in the market are from basswood, buckwheat, cotton, and yellow-poplar, and a number of natural blends, such as those from wild berries and fall flowers.

Not all floral-nectar types of honey are suitable for the table. Several are unfit for food uses. Some, such as strong-flavored smartweed (*Polygonum* spp.) honey, have a restricted market, chiefly because of undesirable odor, which affects the flavor. A few, including mescal, bitterweed (*Helenium tenuifolium,* Nutt.), and chinquapin honeys, are unsalable in the natural state, the mescal because of its offensive odor, the other two because of intense bitterness. They are of use only as winter stores for the bees.

Even buckwheat honey—a favorite with many who have grown up with it, or have acquired a liking for its rich, strong flavor—is occasionally considered an inferior variety in the clover belt.

"Honeydew" honeys are not derived from floral nectar, but from various saccharine exudations, collected when nectar is scarce. They are characterized by a peculiar molasseslike or sorghum-like flavor and high dextrin content, and by having a dextrorotatory effect on polarized light, whereas floral honeys are levorotatory. They bear no relation to honeydew melon.

And, we must admit, a few honeys are actually poisonous. They are chiefly from species of *Kalmia, Rhododendron,* and *Andromeda* and from the yellow (false) jessamine. Fortunately, these seldom reach a market, because they are not ordinarily produced at a time or in sufficient quantities for harvesting and because of the vigilance of the beekeepers. At least one of these poisonous honeys was known to antiquity. L. F. Kebler (1896) cites a passage from the *Anabasis,* Book 4, in which Xenophon in his account of the retreat of the ten thousand in 400 B. C., described the disastrous but not fatal effects on his soldiers from eating honey produced in mountainous country south of the Black Sea. Scientists have concluded that the honey came from one or two species of *Rhododendron.*

THE ANNUAL WORLD production of honey is estimated at more than 800 million pounds. The 10 highest producers are believed to be the United States, the Union of Soviet Socialist Republics, Germany as of 1939, Spain, Canada, Australia, France, United Kingdom, Cuba, and Argentina. Poland, Mexico, and Turkey also produce a great deal of honey.

Production of honey in the United States has been mounting in recent years. It reached 233 million pounds in 1945, nearly 214 million in 1946, and more than 228 million in 1947, when the value (based on prices for "all honey" received by beekeepers) was more than 57 million dollars. The comparable valuation of the 1949 production of nearly 227 million pounds dropped to less than 35 million dollars. In 1945, allowing for imports and exports, more than 254 million pounds was available for consumption.

RECENT INCREASES in the annual production of honey in the United States have been due chiefly to expansion in the number of colonies of bees, which was stimulated by short supplies of sugar and comparatively good prices for honey. Also, increases in bee population were sought for better pollination of legumes grown for seed, many fruits, and some vegetables. But greater numbers of bees have provided more honey; also, since the end of the Second World War, ample supplies of sugar and other sweets have again become available. These developments contributed to a notable surplus of extracted honey (especially of the darker, stronger-flavored varieties) from the 1947 crop and a reported stock on hand in January 1948 of approximately 27 percent of the 1947 production. The reported stocks carried over into the calendar years 1949 and 1950 were even larger. Aware of the need to maintain

our bee population at a high level for adequate pollination of seed crops and realizing that the beekeepers' compensation derives chiefly from the sale of the honey, the Department of Agriculture has undertaken a search for new market outlets for extracted honey.

We have no accurate statistics from the industry on the disposal of the annual honey crop. But reliable estimates place the normal consumption of extracted honey in the homes of this country at 45 to 50 percent of the total. About 15 percent more is directly consumed as section comb and bulk-comb honey. Much of the extracted honey is sold as a finely crystallized spread in cardboard containers.

The remaining 35 to 40 percent of the total crop, all of it extracted, is consumed in various food or other industries. This honey is marketed wholesale, chiefly in 60-pound cans. Nearly 25 percent, or about 50 million pounds a year, is used by the baking industry. Most of the remaining 10 to 15 percent is used in the manufacture of confectionery, ice cream, beverages, alcoholic liquors, honey-cured hams, fruit products, vinegars, and sirups. Some nonfood uses are in chewing tobacco, as a moisture-holding agent in cigarettes, and in cosmetics. Honey has been used as a heavy and incompressible fluid center for golf balls.

THE AVERAGE composition of definitely floral-nectar honey, based on Charles A. Browne's 78 analyses of 33 floral-nectar types, is: Moisture, 17.7 percent; total sugars, 76.4 percent (comprising levulose, 40.5 percent; dextrose, 34.0 percent; and sucrose, 1.9 percent); ash, 0.18 percent; dextrin, 1.5 percent; and total acid (as formic acid), 0.08 percent; leaving 4.1 percent undetermined. The ratio of levulose to dextrose is 1.16 to 1.

The analyses show extracted honey to be inherently a sirup of mixed sugars, for it is 92 to 98 percent sugars and water. As its chief sugars are levulose (also called fructose or fruit sugar) and dextrose (grape sugar), with only comparatively small amounts of sucrose (ordinary table sugar), honey is sometimes referred to as essentially an invert sugar sirup. Invert sugar consists of levulose and dextrose in equal amounts.

But honey is far more than just a concentrated invert sugar sirup. Besides providing a variety of attractive flavors and 2 to 8 percent of substances other than sugars and water, true floral-nectar honeys contain appreciably more levulose than dextrose. Exceptions are infrequent and negligible. This preponderance of the levulose is marked in several commercial honeys (among them those from tupelo, black and purple sage, and fireweed) and is of practical significance. It accounts for the greater sweetening power of the sugars of average honey in comparison with either granulated sugar or invert sugar, and for the notable moisture-absorbing property of honey. Also, a high ratio of levulose to dextrose tends to prevent or at least to retard granulation, or sugaring, meaning the separation of crystals of dextrose hydrate from the liquid honey.

Its comparative sweetening power is of importance to the industrial user, when honey is to be used in other food products. Different results noted in comparing the sweetness of honey with that of sucrose in various products may be explained partly by the effect of other ingredients of the mixtures tested. For example, a particular honey may appear to have a higher relative sweetening power in a plain sirup or candy than in ice cream.

Honey has the following general values: One gallon of average honey contains slightly more than 9 pounds of total sugars. Theoretically, its sweetening power is equivalent to approximately 11.25 pounds of granulated sugar or to 1.67 gallons (measured volume) of this sugar. One pound of average honey has about the same sweetening power as 0.95 pound (15.25 ounces) of sugar. The energy value of 1 pound of this honey is 1,480 cal-

ories, while that of the same weight of sugar is 1,805 calories. The minor constituents of honey include: Ash, or mineral matter; dextrin, which is more gumlike than starch dextrins; acids; and substances for which the quantitative determination is difficult and which make up the undetermined fraction.

Because the ash seldom exceeds 0.25 percent, it brings only small proportions of calcium, potassium phosphate, and other mineral entities to the diet. Traces of iron, copper, and manganese have been found, generally more in the darker than in the lighter honeys. Citric, malic, formic, and acetic acids are present in small amounts, but are sufficiently ionized to add a pleasant sharpness, more or less noticeable in the taste. This sharpness is correlated with the active acidity, technically stated as the pH value. American honeys examined by H. A. Schuette and F. J. Schubert ranged in pH from 3.16 to 4.52, but usual values lay between 3.4 and 4.3. Low pH values correspond to high acid intensity; and the pH scale is logarithmic. Vinegars show pH values from 2.4 to 3.4; therefore, the most acid honeys have an active acidity equal to that of the less acid vinegars. Were it not for their contained sugars, they would taste as sour as some vinegars.

In the undetermined fraction are pigments, including chlorophylls; the enzymes invertase, diastase, and others; additional colloidal substances, made up largely of proteins; and small (sometimes negligible) amounts of vitamins of the B group and vitamin C.

Nutritionally, honey is not a noteworthy source of either vitamins or minerals. Most honeys have been found wholly deficient in vitamins A and D.

The colloidal material ranges from 0.8 percent in buckwheat honey to 0.1 percent or less in very light-colored honeys. Colloids add to the body and viscosity. They increase the tendency to scorch when the honey is heated, however, and they hinder filtration.

When extracted honey leaves the beekeeper, it should be clean and free from evidence of fermentation. Quite generally, the producers strain it, while warm, through cheesecloth or fine-mesh wire screens. A number of larger producers and some commercial packers filter at least part of their output by pressure. Honey that has been strained but not pressure-filtered has a slightly cloudy appearance because of such natural accompaniments as pollen, very fine particles of beeswax, and minute air bubbles.

Also, most of our extracted honeys granulate after standing, especially in a cool place. One of the simplest treatments for clarification is to allow the honey to settle and then draw off the clear middle portion. To produce a clarified honey that sparkles, and at the same time retard granulation, a process of simple pressure filtering was developed in the Department of Agriculture by H. S. Paine and R. E. Lothrop. The honey to be clarified is warmed and mixed with just enough of a suitable grade of diatomaceous earth (an inert filter aid) to permit filtration under moderate pressure, at an industrially practicable speed. Precoating of the filters is practiced, and after the filter cake is formed the amount of filter aid required may vary from none, for clear, light-bodied honeys, to as much as 0.5 percent of the weight of the honey, for darker, heavier types.

Besides such processing, producers and commercial packers try to keep their named honeys uniform in color and flavor. To do so, they commonly have to blend different floral types.

Granulation, or crystallizing of the dextrose, is one of the vexatious accompaniments of honey packing, particularly in the Northern States. The lower temperatures and the natural tendency to granulate of the predominant types of honey in those States increase the problem.

Granulation may be minimized by thoroughly heating the honey to dissolve all crystalline dextrose that might serve as nuclei for further crystalliza-

tion, and by avoiding the introduction of fresh nuclei while bottling. But it should not be heated as high as 160° F. except for flash heating, or above 150° for more than an hour; otherwise the product may be impaired by an effect akin to scorching. Proper heating also tends to safeguard the product against fermentation.

When honey granulates spontaneously, the crystals of dextrose hydrate often are coarse or granular, but some unheated honeys—notably that from alfalfa in the West—crystallize after a time, with the production of very fine crystals of dextrose.

Honey that develops this semisolid but soft consistency has been so popular with consumers as a spread for bread that efforts have been made to produce it artificially by induced controlled crystallization of the dextrose. The products have been variously known as creamed honey, honey butter spread, crystallized honey spread, Dyce-processed honey, and so on.

At Cornell University, E. J. Dyce developed a commercial process of controlled crystallization. The licensing rights to it have been assigned to the Cornell Research Foundation. The process consists of heating the honey to 145° F. for 10 minutes or to 140° for 30 minutes to effect a "commercial sterilization" and to prevent subsequent fermentation; seeding the batch at about 75° with crystals of dextrose hydrate to hasten crystallization, because fineness of "grain" depends on rapid crystal formation; and cooling to about 57°, the best temperature for crystallization, and holding at that temperature for several days.

OTHER THAN in the home, the chief use of honey is in the bakery. Generally, the lighter-colored honeys are packed for home use, and bakeries and other industrial users get the darker ones of stronger flavor. Many bakers believe that the honey flavor of the darker sorts carries over into the baked goods better than that of mild, light ones.

Large quantities of honey are used in crushed-wheat and other specialty breads and in honey-graham crackers. Bread that has 6 percent or more of honey (based on weight of flour) is said to have a crust of improved color and flavor and of chewy texture; it also retains moisture better and does not get stale so soon. In such items as honey cakes and jumbles, for which higher proportions of honey are indicated, those desirable effects are more apparent. Distinctive flavor and aroma (determined by the type of honey used), "tenderness" of the crumb, and improvement with age are recognized benefits from the use of the larger proportions of honey. Fruit cakes for the holiday trade, intended to be kept for weeks or even months, and of unusually fine flavor and quality can be made with 18 to 24 pounds of honey to 100 pounds of flour.

In using honey in baking and in other cookery, allowance is made for its water content. One gallon (11.8 pounds) of average honey contains approximately 2 pounds 2 ounces, or 1 quart, of water.

HONEY HAS much to contribute to present-day candy making, but great care and skill are required to prevent scorching during the boiling of the candy. The right honeys add greatly to the flavor and quality of nougats and other chewy types. Originally, nougat was made with honey as the sole source of sugars, and manufacturers of fine candies are willing to pay the price for the kind of honey required. Before 1940, Grecian honey, produced from wildthyme bloom in the vicinity of Mount Hymettus, was imported by one of our makers of fine nougat.

Large quantities of ice cream are made with the milder honeys in areas where they are abundant. P. H. Tracy, H. A. Roehe, and F. P. Sanmann, at the University of Illinois Experiment Station, found that excellent ice creams with appealing flavors could be made by using up to 18 pounds of honey to 100 pounds of mix.

Wine can be made from honey. A red sweet wine, for ritualistic use, is made from buckwheat honey diluted with water. Mead, hydromel, metheglin, pyment, and cyser are variations of honey wine; their production goes back to the dawn of history. Press announcements in 1948 said that the mead, pyment, and cyser industry of England is being revived, but along modern scientific lines.

Vinegar can also be made from diluted honey, in a manner paralleling the making of cider vinegar from fermented apple juice. Some of the scientific aspects of the process were investigated by F. W. Fabian of the Michigan Agricultural Experiment Station. After diluting the honey with roughly 6 times its weight of water, the sirup (containing approximately 12 percent of honey solids) is heated to boiling. After it has cooled, there are added a small quantity of yeast-nutrient salts (1 ounce each of ammonium phosphate and potassium tartrate for every 150 pounds of solution) and a fermentation starter of pure yeast. The acetic acid (vinegar) production is assisted by the addition of mother of vinegar.

HONEY can be used as a flavorful source of sugars for preserving fruits, but ordinarily it is advisable to provide not more than one-half of the total sugar from this source. Research in the Department of Agriculture showed that, although the flavors of choice honeys and of many common fruits blend well, higher proportions of honey tend to mask more delicate fruit flavors. In making these products, it is advisable to concentrate the fruit or fruit-juice base, preferably in a vacuum pan, before adding the honey.

Bottled carbonated soft drinks can be made with honey modified by special processing. If untreated honeys are used in such beverages, they tend to become cloudy shortly after being made, and sediment may form. But sirups satisfactory for this purpose and for fountain uses can be prepared by removing colloidal substances and undesirable flavors and pasteurizing. The honey is diluted with water to approximately 60 percent solids content and warmed, and colloidal substances are precipitated by mixing with it a few tenths of 1 percent (based on the weight of honey) of colloidal bentonite clay (previously mixed with water to form a cream). After removing the colloids by pressure filtering, the clear sirup is bottled and heat-sterilized. The addition of some filter aid is required; and for strong, dark honeys, treatment with 1 percent or more of activated carbon to modify flavor and color is often desirable. Sweetclover and buckwheat sirups, with and without acidulation (to pH 3.0), are satisfactory sweeteners for a number of types of bottled soft drinks.

I have mentioned the use of honey in some chewing tobaccos. As a humectant agent in cigarettes, apparently a very small amount of honey in the tobacco serves to maintain the desired moisture content of the product.

Milk and honey combine excellently and supplement each other nutritionally. Surprisingly, however, few firms have thought to market such a product. Dr. F. W. Schlutz and associates, working in the pediatrics department of the University of Chicago Hospital, obtained favorable results with formulas in which honey supplied the sugars in the diet of infants. They found that the energy-giving sugars of honey quickly became available, but, unlike other rapidly assimilated sugars also tested, honey did not load the infants' blood with an excessive amount of sugar. With honey, the sugars available to the body rose to a moderately high point and were maintained at this desirable level for a longer time than with any other carbohydrate tested.

Technological obstacles, the difficulty of producing a shelf-stable product, provide the chief reasons why such combinations as honey-sweetened condensed milks and wheys have not been manufactured. Department of Agriculture researchers made condensed

milks and wheys with honey in pilot-plant quantities. Canned modified milks for infants and spray-dried combinations of milk and honey and of skim milk and honey also have been produced by them. Their work has shown that sweetened condensed milks of excellent flavors and quality, when freshly made, can be made from choice honeys, but the canned products have tended to darken and thicken in a short time. In canned modified milks, high-quality honeys can provide an excellent source of 8 percent of available carbohydrates.

Spray-dried skim-milk and honey powders appear to hold great promise because of ease of handling and dispensing and excellent flavor. Because they can be made with different ratios of honey solids to milk solids, and possess high concentration and convenient form, they should find use in baking and in confectionery. Producers of ready-mixed cakes and similar dry mixes would doubtless have included honey in certain formulas if a dehydrated honey powder had been commercially available. A skim-milk (or milk) and honey powder with a ratio of honey solids to milk solids of 40 to 60 or 50 to 50 should serve well for such use. The compositions of two spray-dried skim-milk and honey powders, having 20 to 80 and 42 to 58 ratios of honey solids to milk solids, and of one 20-to-80 whole-milk and honey powder are shown in the accompanying table. The second of these powders, containing more than 21 percent of skim-milk proteins and nearly 69 percent of sugars, of which 39 percent are honey sugars, should prove of interest and value to confectioners, bakers, and manufacturers of ready mixes and similar foodstuffs.

Because of the deleterious effects of oxygen in the air, such precautions as gas-pack (packing in an atmosphere of nitrogen) or vacuum-pack canning should be observed in packing dried whole-milk and honey powders. These precautions are practiced in the commercial canning of the ordinary dried whole milks, to avoid rancidity and tallowy flavor.

Composition of spray-dried milk and honey powders [1]

	Skim-milk and honey powders		*Whole-milk and honey powder*
	Percent	*Percent*	*Percent*
Moisture	3.2	1.6	2.5
Total solids	96.8	98.4	97.5
From honey	19.4	41.3	19.5
From milk	77.4	57.1	78.0
Butterfat	.8	.6	20.0
Milk proteins	28.6	21.3	21.4
Sugars, total [2]	60.3	68.8	50.4
Lactose	41.7	29.7	31.6
Levulose	9.2	20.5	9.3
Dextrose	8.9	16.7	9.0
Sucrose	.5	1.9	.5
Ash (mineral matter)	[3] 6.4	4.7	[3] 5.0
Undetermined	.7	3.0	.7

[1] In part calculated.

[2] Sweetening effect of the total sugars is calculated (in terms of pounds of sucrose per 100 pounds of product) for the 3 powders at 31, 55, and 29 pounds.

[3] Includes calcium carbonate added to the honey. PH values of the mixtures before drying were 6.2, 6.1, and 6.7.

Spreads consisting of mixtures of heavy (dairy) cream and honey, and of creamery butter and honey have been manufactured from time to time. P. H. Tracy, at the University of Illinois, produced a satisfactory spread with 42 percent of honey and 58 percent of heavy cream. A product containing upward of 20 percent sweet-cream butter mixed with mild-flavored honey appears to have been well received. Honey and peanut-butter mixtures when freshly prepared make a tasty and nutritious spread. The products, however, require special processing to retard development of off-flavor.

HONEYS FROM smartweed, varieties of eucalyptus, horsemint, and some blends of autumn flowers, although wholesome and, with the exception of eucalyptus, produced in substantial

volume, do not have satisfactory marketability because of objectionable flavor or odor. The demand for buckwheat honey is affected by its strong flavor and dark color.

Treatments to improve unattractive honeys have been developed in Australia and New Zealand and by W. W. Somerford and others in the United States. A feature common to most such processes is to treat the heated diluted honey with activated carbon. That serves to lighten the color and to remove some flavor.

In 1948 the heavy carry-over of the 1947 crop of honey, including millions of pounds of types hard to market, posed a serious economic problem to the beekeeping industry. On the recommendation of representatives of the industry, the Department of Agriculture set up a project, under the Research and Marketing Act, at the Eastern Regional Research Laboratory to develop industrially applicable processes to modify the less marketable honeys so as to make them acceptable primarily to bakers.

Two types of processing were offered at the completion, in 1950, of one phase of the research. Diluting the honey, adding a few tenths of 1 percent of bentonite clay to the honey solution heated to 150° F., agitating for 20 to 30 minutes, pressure-filtering with the help of filter aid, and reconcentrating under vacuum to honey density improve the flavor and color of honeys from buckwheat, fall flowers, and horsemint for bakery use and retain a desirable honey flavor. The products may be standardized as to moisture content, acidity, and flavor for a specified use in food industries.

The second process offered deflavors the honey completely. The diluted honey is treated with a few hundredths of 1 percent of calcium hydroxide to adjust the acidity of the sirup to pH 4.3 to facilitate the precipitation of honey colloids. It is then heated with a suitable activated carbon in proportions varying with different honeys from less than 1 to 3 percent for 30 minutes and pressure-filtered. The density may be reconstituted under vacuum. The product is a bland, light-colored sirup of honey sugars, with little if any of the original flavor, even when made from smartweed honey, whose objectionable flavor components are very difficult to remove. Reconcentration of the filtered sirup requires the evaporation of upwards of 21 pounds of water to 100 pounds of the sirup. Since few small honey packers are equipped for such an operation, it apparently would be more practical for them to heat-sterilize and can the filtered sirups and market them for use by bakers or in confectionery or ice creams.

Suitably modified honey sirups could provide a new source of wholesome sweetness of attractive flavor for use as fountain sirups, in the bakery, and for bottled beverages.

To one who fully appreciates the delicate flavors and ethereal fragrance of honey newly ripened from wholesome floral sources, no man-made confection equals honey in the comb. The greatest appeal of honey is its taste, which comprises far more than sweetness plus the aroma of flowers. Piquant tartness stemming from its natural acids enhances the flavor and is an important taste component. The full body of well-ripened honey, which conveys a sense of smoothness and substance to the tongue, also plays a part in the sensation of a satisfying taste effect.

As a confection, comb honey appeals to those persons who esteem moderation. The great sweetness and palpable body and concentration quickly satisfy the normal appetite for food sugars. A little goes a long way.

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